Energy Literacy

Essential Principles and Fundamental Concepts for Energy Education

A FRAMEWORK FOR ENERGY EDUCATION FOR LEARNERS OF ALL AGES

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ABOUT THIS GUIDE

Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education presents energy concepts that, if understood and applied, will help individuals and communities make informed energy decisions.

Energy is an inherently interdisciplinary topic. Concepts fundamental to understanding energy arise in nearly all, if not all academic disciplines. This guide is intended to be used across disciplines. Both an integrated and **systems-based approach** to understanding energy are strongly encouraged.

Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education identifies seven Essential Principles and a set of Fundamental Concepts to support each principle. This guide does not seek to identify all areas of energy understanding, but rather to focus on those that are essential for all citizens. The Fundamental Concepts have been drawn, in part, from existing education standards and benchmarks.

The intended audience for this document is anyone involved in energy education. Used in formal educational environments, this guide provides direction without adding new concepts to the educator's curriculum. This guide is not a curriculum. The Essential Principles and Fundamental Concepts offer a framework upon which curricula can be based without prescribing when, where or how content is to be delivered.

Intended use of this document as a guide includes, but is not limited to, formal and informal energy education, standards development, curriculum design, assessment development and educator trainings.

Development of this guide began at a workshop sponsored by the Department of Energy (DOE) and the American Association for the Advancement of Science (AAAS) in the fall of 2010. Multiple federal agencies, non-governmental organizations, and numerous individuals contributed to the development through an extensive review and comment process. Discussion and information gathered at AAAS, WestEd and DOE-sponsored Energy Literacy workshops in the spring of 2011 contributed substantially to the refinement of the guide.

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WHAT IS ENERGY LITERACY?

Energy literacy is an understanding of the nature and role of energy in the universe, and in our lives. Energy literacy is also the ability to apply this understanding to answer questions and solve problems.

An energy-literate person:

- can trace energy flows and think in terms of energy **systems**
- knows how much energy he or she uses, for what, and where the energy comes from
- can assess the credibility of information about energy
- can communicate about energy and energy use in meaningful ways
- is able to make informed energy and energy use decisions based on an understanding of impacts and consequences
- continues to learn about energy throughout his or her life

ENERGY LITERACY IS A PART OF SOCIAL & NATURAL SCIENCE LITERACY

A comprehensive study of energy must be interdisciplinary. Energy issues cannot be understood and problems cannot be solved by using only a natural science or engineering approach. Energy issues often require an understanding of civics, history, economics, sociology, psychology and politics in addition to science, math and technology.

Just as both social and natural science are a part of energy literacy, energy literacy is an essential part of being literate in the social and natural sciences. References to energy can be found in National Education Standards in nearly all academic disciplines.

WHY DOES ENERGY LITERACY MATTER?

A better understanding of energy can:

- lead to more informed decisions
- improve the security of a nation
- promote economic development
- lead to sustainable energy-use
- reduce environmental risks and negative impacts
- help individuals and organizations save money

Without a basic understanding of energy, energy sources, generation, use and conservation strategies, individuals and communities cannot make informed decisions on topics ranging from smart energy use at home and consumer choices to national and international energy policy. Current national and global issues such as the fossil fuel supply and climate change highlight the need for energy education.

HOW DO WE KNOW WHAT WE KNOW ABOUT ENERGY?

Social and natural scientists have **system**atically developed a body of knowledge about energy through a process much the same as that used by scientific disciplines in general.

Social and natural scientists formulate and test explanations of nature using observation, experiment, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement, for most major ideas, there is substantial experimental and observational confirmation. These major ideas are not likely to change greatly in the future. Scientists do adjust and refine their ideas about nature when they encounter new experimental evidence that does not match existing models, rejecting the notion of attaining absolute truth and accepting uncertainty as part of nature. The modification of ideas, rather than their outright rejection, is the norm in science, as powerful constructs tend to survive, grow more precise, and become widely accepted.

In areas where active research is being pursued and in which there is not a great deal of experimental or observational evidence and understanding, it is normal for scientists to differ with one another about the interpretation of evidence being considered. Different scientists might publish conflicting experimental results or might draw different conclusions from the same data. Ideally, scientists acknowledge such conflict and work toward finding evidence that will resolve their disagreement. In this way, communities of social and natural scientists form self-correcting networks, working toward an ever-better understanding of the social and natural universe.

Part of scientific inquiry is to evaluate the results of scientific investigations, experiments, observations, theoretical models and the explanations proposed by other scientists. Evaluation includes reviewing the experimental procedures, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. Although scientists may disagree about explanations of phenomena, interpretations of data, or the value of rival theories, they do agree that questioning, response to criticism, and open communication are integral to the process of science. As knowledge evolves, major disagreements are eventually resolved through such interactions.

A BRIEF HISTORY OF HUMAN ENERGY USE

Producers in a food chain−like plants, algae and cyanobacteria−capture energy from the Sun. Nearly all organisms rely on this energy for survival. Energy flow through most food chains begins with this captured solar energy. Some of this energy is used by organisms at each level of the food chain, much is lost as heat, and a small portion is passed down the food chain as one organism eats another.

Over time, humans have developed an understanding of energy that has allowed them to harness it for uses well beyond basic survival.

The first major advance in human understanding of energy was the mastery of fire. The use of fire to cook food and heat dwellings, using wood as the fuel, dates back at least 400,000 years.[1] The burning of wood and other forms of biomass eventually led to ovens for making pottery, and the refining of metals from ore. The first evidence of coal being burned as a fuel dates back approximately 2400 years.[2]

After the advent of fire, human use of energy per capita remained nearly constant until the Industrial Revolution of the 19th century. This is despite the fact that, shortly after mastering fire, humans learned to use energy from the Sun, wind, water, and animals for endeavors such as transportation, heating, cooling and agriculture.

The invention of the steam engine was at the center of the Industrial Revolution. The steam engine converted the chemical energy stored in wood or coal into motion energy. The steam engine was widely used to solve the urgent problem of pumping water out of coal mines. As improved by James Watt, Scottish inventor and mechanical engineer, it was soon used to move coal, drive the manufacturing of machinery, and power locomotives, ships and even the first automobiles.[3] It was during this time that coal replaced wood as the major fuel supply for industrialized society. Coal remained the major fuel supply until the middle of the 20th century when it was overtaken by oil.

The next major energy revolution was the ability to generate electricity and transmit it over large distances. During the first half of the 19th century British physicist, Michael Faraday demonstrated that electricity would flow in a wire exposed to a changing magnetic field, now known as Faraday's Law. Humans then understood how to generate electricity. In the 1880s, Nikola Tesla, a Serbian-born electrical engineer designed alternating current (AC) motors and transformers that made long distance transmission of electricity possible. Humans could now generate electricity on a large scale, at a single location, and then transmit that electricity efficiently to many different locations. Electricity generated at Niagara Falls, for example, could be used by customers all over the region.

Although hydropower, largely in the form of water wheels, has been in use by human society for centuries, hydroelectricity is a more recent phenomenon. The first hydroelectric power plants were built at the end of the 19th century and by the middle of the 20th century were a major source of electricity. As of 2010, hydropower produced more than 15% of the world's electricity.[4]

Like hydropower, humans have been using energy from wind to power human endeavors for centuries, but have only recently begun harnessing wind energy to generate electricity. Wind energy propelled boats along the Nile River as early as 5000 B.C. By 200 B.C., simple windmills in China were pumping water, while vertical-axis windmills with woven reed sails were grinding grain in Persia and the Middle East. Windmills designed to generate electricity, or wind turbines,

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[1] Bowman DM, Balch JK, Artaxo P *et al.* Fire in the Earth system. *Science*. 2009;324(5926):481–4

[2] Metalworking and Tools", in: Oleson, John Peter (ed.): *The Oxford Handbook of Engineering and Technology in the Classical World*, Oxford University Press, ISBN 978-0-19-518731-1, pp. 418–38 (432)

[3] AAAS, 10J/M2

[4] Source of data is the U.S. Energy Information Administration (http://www.eia.doe.gov) unless otherwise noted.

appeared in Denmark as early as 1890. Currently, wind provides almost 2% of the world's electricity.[5]

In the 20th century, Einstein's Theories of Relativity and the new science of quantum mechanics brought with them an understanding of the nature of matter and energy that gave rise to countless new technologies. Among these technologies were the nuclear power plant and the solar or photovoltaic cell. Both of these technologies emerged as practical sources of electricity in the 1950s. Nuclear energy quickly caught on as a means of generating electricity. Today, nuclear energy generates almost 15% of the world's electricity. Solar energy provides less than 1% of the world's electricity. Solar is the only primary energy source that can generate electricity without relying on Faraday's Law. Particles of light can provide the energy for the flow of electrons directly.

Humans have also managed to harness the geothermal energy of Earth to produce electricity. The first geothermal power plant was built in 1911 in Larderello, Italy. Geothermal energy is a result of the continuous radioactive decay of unstable elements beneath Earth's surface and gravitational energy associated with Earth's mass. The radioactive decay and gravitational energy produce thermal energy that makes its way to the surface of Earth, often in the form of hot water or steam.

Modern biofuels are another way humans have found to harness energy for use beyond basic survival. Biofuels are plant materials and animal waste used as fuel. For example, ethanol is a plant-based fuel used more and more commonly in vehicles, usually in conjunction with petroleum-based fuels.

Although humans have found many different sources of energy to power their endeavors, fossil fuels remain the major source by a wide margin. The three fossil fuel sources are coal, oil and natural gas. Oil has been the major fuel supply for industrialized society since the middle of the 20th century and provides more of the energy used by humans than any other source. Coal is second on this list followed closely by natural gas. Together they accounted for more than 85% of the world's energy use in 2004.

Industrialization and the rise in access to energy resources have taken place at very disparate rates in different countries around the world. For example, as of 2006, there were 1.6 billion people on Earth with no access to electricity.[6]

As with any human endeavor, the harnessing of energy resources and the production of electricity has and will have impacts and consequences, both good and bad. Awareness of the energy used to grow, process, package and transport food, or the energy used to treat water supplies and waste water is important if society is to minimize waste and maximize efficiency. These are just a few examples of the many energy issues people can become informed about.

Human society has, and will continue to develop rules and regulations to help minimize negative consequences. As new information comes to light and new technologies are developed, energy policies are reevaluated, requiring individuals and communities to make decisions. This guide outlines the understandings necessary for these decisions to be informed.

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[5] World Wind Energy Report, World Wind Energy Association, February, 2009.

[6] International Energy Agency, World Energy Outlook, 2006

ENERGY LITERACY

THE ESSENTIAL PRINCIPLES AND FUNDAMENTAL CONCEPTS

<u>A note on use of the principles and concepts</u>: The principles are meant to be broad categories representing big ideas. Each fundamental concept is intended to be unpacked and applied as appropriate for the learning audience and setting. For example, teaching about the various sources of energy (Fundamental Concept 4.1) in a 3rd grade classroom, in a 12th grade classroom, to visitors of a museum, or as part of a community education program will look very different in each case. Additionally, the concepts are not intended to be addressed in isolation. A given lesson on energy will most often connect to many of the concepts.

1. Energy is a physical quantity that follows precise natural laws.

1.1 **<u>Energy is a quantity that is transferred from system to system</u>.** Energy is the ability of a **system** to do work. A **system** has done work if it has exerted a force on another **system** over some distance. When this happens energy is transferred from one **system** to another. At least some of the energy is also transformed from one type into another during this process. One can keep track of how much energy transfers into or out of a **system**.

1.2 **<u>The energy of a system or object that results in its temperature is called thermal energy</u>.** When there is a net transfer of energy from one **system** to another, due to a difference in temperature, we call the energy transferred heat. Heat transfer happens in three ways: convection, conduction and radiation. Like all energy transfer, heat transfer involves forces exerted over a distance at some level as **systems** interact.

1.3 **<u>Energy is neither created nor destroyed</u>.** The change in the total amount of energy in a **system** is always equal to the difference between the amount of energy transferred in and the amount transferred out. The total amount of energy in the universe is finite and constant.

1.4 **<u>Energy available to do useful work decreases as it is transferred from system to system</u>.** Although energy is neither created nor destroyed, its **quality** degrades over time. During all transfers of energy between two **systems**, some energy is lost to the surroundings. In a practical sense, this lost energy has been "used up," even though it is still around somewhere. A more **efficient system** will lose less energy, up to a theoretical limit.

1.5 **<u>Energy comes in different forms and can be divided into categories</u>.** Forms of energy include light energy, elastic energy, chemical energy and more. There are two categories that all energy falls into, kinetic and potential. Kinetic describes types of energy associated with motion and the word potential describes energy possessed by an object or **system** due to its position relative to another object or **system** and forces between the two. Some forms of energy are part kinetic and part potential energy.

1.6 **<u>Chemical and nuclear reactions involve transfer and transformation of energy</u>.** The energy associated with **nuclear reactions** is much larger than that associated with **chemical reactions** for a given amount of mass. **Nuclear reactions** take place at the centers of stars, in nuclear bombs and in both fission and fusion-based nuclear reactors. **Chemical reactions** are pervasive in living and non-living Earth **systems**.

1.7 **<u>Many different units are used to quantify energy</u>.** As with other physical quantities, many different units are associated with energy. For example, joules, calories, ergs, kilowatt-hours and BTUs are all units of energy. Given a quantity of energy in one set of units, one can always convert it to another (E.g., 1 calorie = 4.186 joules).

1.8 **<u>Power is a measure of energy transfer rate</u>**. It is useful to talk about the rate at which energy is transferred from one **system** to another (energy per time). This rate is called power. One joule of energy transferred in one second is called a Watt (I.e., 1 joule/second = 1 Watt).

2. Physical processes on Earth are the result of energy flow through the Earth system.

2.1 **<u>Earth is constantly changing as energy flows through the system</u>**. Geologic, fossil and ice records provide evidence of significant changes throughout Earth's history. These changes are always associated with changes in the flow of energy through the Earth **system**. Both living and non-living processes have contributed to this change.

2.2 **<u>Sunlight, gravitational potential, decay of radioactive isotopes, and rotation of the Earth are the major sources of energy driving physical processes on Earth.</u>** Sunlight is a source external to Earth while radioactive isotopes and gravitational potential, with the exception of tides, are internal. Radioactive isotopes and gravity work together to produce geothermal energy beneath Earth's surface. Earth's rotation influences global flow of air and water.

2.3 **<u>Earth's weather and climate is mostly driven by energy from the Sun</u>.** For example, unequal warming of Earth's surface and atmosphere by the Sun drives convection within the atmosphere, producing winds, and influencing ocean currents.

2.4 **<u>Water plays a major role in the storage and transfer of energy in the Earth system</u>.** This is due to water's prevalence, high heat capacity and the fact that phase changes of water occur regularly on Earth. The Sun provides the energy that drives the water cycle on Earth.

2.5 **<u>Movement of matter between reservoirs is driven by Earth's internal and external sources of energy</u>.** These movements are often accompanied by a change in the physical and chemical properties of the matter. Carbon, for example, occurs in carbonate rocks such as limestone, in the atmosphere as carbon dioxide gas, in water as dissolved carbon dioxide, and in all organisms as complex molecules that control the chemistry of life. Energy drives the flow of carbon between these different **reservoirs**.

2.6 **<u>Greenhouse gases affect energy flow through the Earth system</u>.** Greenhouse gases in the atmosphere, such as carbon dioxide and water vapor, are transparent to much of the incoming Sunlight but not to the infrared light from the warmed surface of Earth. These gases play a major role in determining average global surface temperatures. When Earth emits the same amount of energy as it absorbs its average temperature remains stable.

2.7 **<u>The effects of changes in Earth's energy system are often not immediately apparent</u>.** Responses to changes in Earth's energy **system**, input versus output, are often only noticeable over the course of months, years or even decades.

3. Biological processes depend on energy flow through the Earth system.

3.1 **The Sun is the major source of energy for organisms and the ecosystems of which they are a part.** Producers such as plants, algae and cyanobacteria use the energy from sunlight to make organic matter from carbon dioxide and water. This establishes the beginning of energy flow through almost all food webs.

3.2 **Food is a biofuel used by organisms to acquire energy for internal living processes.** Food is composed of molecules that serve as **fuel** and building material for all organisms as energy stored in the molecules is released and used. The breakdown of food molecules enables cells to store energy in new molecules that are used to carry out the many functions of the cell and thus the organism.

3.3 **Energy available to do useful work decreases as it is transferred from organism to organism.** The chemical elements that make up the molecules of living things are passed through food chains and are combined and recombined in different ways. At each level in a food chain, some energy is stored in newly made chemical structures, but most is dissipated into the environment. Continual input of energy, mostly from sunlight, keeps the process going.

3.4 **Energy flows through food webs in one direction, from producers to consumers and decomposers.** An organism that eats lower on a food chain is more energy **efficient** than one eating higher on a food chain. Eating producers is the lowest, and thus most energy **efficient**, level at which an animal can eat.

3.5 **Ecosystems are affected by changes in the availability of energy and matter.** The amount and kind of energy and matter available constrains the distribution and abundance of organisms in an eco**system** and the ability of the eco**system** to recycle materials.

3.6 **Humans live within Earth's ecosystems.** Increasingly, humans modify the energy balance of Earth’s eco**systems**. The changes happen, for example, as a result of changes in agricultural and food processing technology, consumer habits, and human population size.

4. Various sources of energy can be used to power human activities, and often this energy must be transferred from source to destination.

4.1 **<u>Humans transfer and transform energy from the environment into forms useful for human endeavors</u>.** The **primary sources** of energy in the environment include **renewable** sources such as sunlight, wind, moving water, and geothermal energy. **Primary sources** also include **fuels** like coal, oil, natural gas, uranium and **biomass**. All **primary source fuels** except **biomass** are non-**renewable**.

4.2 **<u>Human use of energy is subject to limits and constraints</u>.** Industry, transportation, urban development, agriculture, and most other human activities are closely tied to the amount and kind of energy available.The availability of energy resources is constrained by the distribution of natural resources, availability of affordable technologies and socio-economic policies and status.

4.3 **<u>Fossil and bio fuels are organic matter that contain energy captured from sunlight</u>.** The energy in **fossil fuels** such as oil, natural gas and coal comes from energy that producers such as plants, algae and cyanobacteria, captured from sunlight long ago. The energy in **biofuels** such as food, wood, and ethanol comes from energy that producers captured from sunlight very recently. Energy stored in these **fuels** is released during **chemical reactions**, such as combustion and respiration, which also release carbon dioxide into the atmosphere.

4.4 **<u>Humans transport energy from place to place</u>. Fuels** are often not used at their source but are transported, sometimes over long distances. **Fuels** are transported primarily by pipelines, trucks, ships, and trains. Electrical energy can be generated from a variety of energy resources and can be transformed into almost any other form of energy. Electric circuits are used to distribute energy to distant locations. Electricity is not a **primary energy source**, but a means of transmitting energy.

4.5 **<u>Electricity is usually generated in one of two ways</u>**. When a magnet moves or magnetic field changes relative to a coil of wire, electrons are induced to flow in the wire. Most human generation of electricity happens in this way. Electrons can also be induced to flow through direct interaction with light particles; this is the basis upon which a solar cell operates.

4.6 **<u>Humans intentionally store energy for later use in a number of different ways</u>.** Examples include batteries, water **reservoirs**, compressed air, hydrogen and thermal storage. Storage of energy involves many technological, environmental and social challenges.

4.7 **<u>Different sources of energy and the different ways energy can be transformed, transported and stored each have different benefits and drawbacks</u>.** A given energy **system**, from source to sink, will have an inherent level of energy **efficiency**, monetary cost and environmental risk. Each **system** will also have national security, access and equity implications.

5. Energy decisions are influenced by economic, political, environmental and social factors.

5.1 **<u>Decisions concerning the use of energy resources are made at many levels</u>.** Humans make individual, community, national and international energy decisions. Each of these levels of decision making have some common and some unique aspects. In the developed world, decisions made beyond the individual level usually involve a formally established process.

5.2 **<u>Energy infrastructure has inertia</u>.** The decisions that governments, corporations, and individuals made in the past have created today's energy infrastructure. The large amount of money, time, and technology invested in these **systems** make changing the infrastructure difficult, but not impossible. The decisions of one generation both provide and limit the range of possibilities open to the future generations.

5.3 **<u>Energy decisions can be made using a systems-based approach</u>.** As individuals and societies make energy decisions they can consider the costs and benefits of each decision. Some costs and benefits are more obvious than others. Identifying all costs and benefits requires a careful and informed **systems-based approach** to decision making.

5.4 **<u>Energy decisions are influenced by economic factors</u>.** Monetary costs of energy affect energy decision making at all levels. Energy exhibits characteristics of both a **commodity** and a **differentiable product**. Energy costs are often subject to market fluctuations and energy choices made by individuals and societies affect these fluctuations. Cost differences also arise as a result of differences in energy source and as a result of tax-based incentives and rebates.

5.5 **<u>Energy decisions are influenced by political factors</u>. Political** factors play a role in energy decision making at all levels. These factors include, but are not limited to, governmental structure and power balances, actions taken by politicians, and partisan-based or self serving actions taken by individuals and groups.

5.6 **<u>Energy decisions are influenced by environmental factors</u>.** Environmental costs of energy decisions affect energy decision making at all levels. All energy decisions have environmental consequences. These consequences can be positive or negative.

5.7 **<u>Energy decisions are influenced by social factors</u>.** Questions of ethics, morality and social norms affect energy decision making at all levels. Social factors often involve economic, **political** and environmental factors.

6. The amount of energy used by human society depends on many factors.

6.1 **<u>Conservation of energy has two very different meanings</u>.** There is the physical law of conservation of energy, also known as the First Law of Thermodynamics. This law says that the total amount of energy in the Universe is constant. Conserving energy is also commonly used to mean the decreased use of societal energy resources. When speaking of people conserving energy this second meaning is always intended.

6.2 **<u>One way to manage energy resources is through conservation</u>**. Conservation includes reducing wasteful energy use, using energy for a given purpose more **efficiently**, making strategic choices as to sources of energy and reducing energy use altogether.

6.3 **<u>Human demand for energy is increasing</u>.** Population growth, industrialization and socio-economic development result in increased demand for energy. Societies have choices with regard to how they respond to this increase. Each of these choices has consequences.

6.4 **<u>Earth has finite energy resources</u>.** Increasing human energy consumption places stress on the natural processes that renew some energy resources and it depletes those that cannot be renewed.

6.5 **<u>Social and technological innovation affects the amount of energy used by human society</u>.** The amount of energy society uses per capita or in total can be decreased. Decreases will happen as a result of technological and social innovation and change. Decreased use of energy does not equate to decreased quality of life. In many cases it will be associated with increased quality of life in the form of increased economic and national security, reduced environmental risks and monetary savings.

6.6 **<u>Behavior and design affect the amount of energy used by human society</u>.** There are actions individuals and society can take to conserve energy. These actions might come in the form of changes in behavior or in changes to the design of technology and infrastructure. Some of these actions have more impact than others.

6.7 **<u>Products and services carry with them embedded energy</u>.** The energy needed for the entire lifecycle of a product or service is called the "embedded" or "embodied" energy. An accounting of the embedded energy in a product or service along with knowledge of the source(s) of the energy is essential when calculating the amount of energy used and in assessing impacts and consequences.

6.8 **<u>Amount of energy used can be calculated and monitored</u>**. An individual, organization or government can monitor, measure and control energy use in many ways. Understanding utility costs, knowing where consumer goods and food come from, and understanding energy **efficiency** as it relates to home, work and transportation are essential to this process.

7. The quality of life of individuals and societies is affected by energy choices.

7.1 **<u>Economic security is impacted by energy choices</u>.** Individuals and society continually make energy choices that have economic consequences. These consequences come in the form of monetary cost in general and in the form of price fluctuation and instability specifically.

7.2 **<u>National security is impacted by energy choices</u>.** The security of a nation is dependent, in part, on the sources of that nation's energy supplies. For example, a nation that has diverse sources of energy that come mostly from within its borders is more secure than a nation largely dependent on foreign energy supplies.

7.3 **<u>Environmental quality is impacted by energy choices</u>.** Energy choices made by humans have environmental consequences. The quality of life of humans and other organisms on Earth can be significantly affected by these consequences.

7.4 **<u>Increasing demand for and limited supplies of fossil fuels affects quality of life</u>.** **Fossil fuels** provide the vast majority of the world's energy. **Fossil fuel** supplies are limited. If society has not transitioned to sources of energy that are **renewable** before depleting Earth's **fossil fuel** supplies, it will find itself in a situation where energy demand far exceeds energy supply. This will have many social and economic consequences.

7.5 **<u>Access to energy resources affects quality of life</u>.** Access to energy resources, or lack thereof, affects human health, access to education, socio-economic status, gender equality, global partnerships and the environment.

7.6 **<u>Some populations are more vulnerable to impacts of energy choices than others</u>.** Energy decisions have economic, social and environmental consequences. Poor, marginalized or underdeveloped populations can most benefit from positive consequences and are the most susceptible to negative consequences.

Key Definitions

Definitions given here are for the purposes of this document and are not necessarily complete or exhaustive. Words or phrases included here are those for which there may be some confusion as to the meaning intended.

Biofuel – A **fuel** produced from **biomass** or **biomass** used directly as a **fuel**. Compare **Biomass**.

Biomass – Organic nonfossil material of biological origin. Compare **Biofuel**.

Chemical Reaction – A process that involves changes in the structure and energy content of atoms, molecules, or ions but not their nuclei. Compare **Nuclear Reaction**.

Commodity – A good for which there is demand, but which is supplied without qualitative differentiation across a market. The market treats it as equivalent or nearly so no matter who produces it.

Conservation of Energy – See Fundamental Concept 6.1.

Degrade (as in energy) – The transformation of energy into a form in which it is less available for doing work.

Differentiable Product – A product whose price is not universal. A product whose price is based on factors such as brand and perceived quality.

Efficiency or **Efficient** – The use of a relatively small amount of energy for a given task or purpose.

Embedded or **Embodied Energy** – See Fundamental Concept 6.7.

Energy – See Fundamental Concept 1.1.

Energy Carrier – A source of energy that has been subject to human induced energy transfers or transformations. Examples include hydrogen **fuel** and electricity. Compare **Primary Energy Source**.

Fossil Fuel – **Fuel** formed from **biomass** by a process taking millions of years or longer.

Fuel – A material substance that possesses internal energy that can be transferred to the surroundings for specific uses. Included are petroleum, coal, and natural gas (the **fossil fuels**), and other materials, such as uranium, hydrogen and **biofuels**.

Geothermal Energy – See Fundamental Concept 2.2.

Heat – See Fundamental Concept 1.2.

Kinetic Energy – See Fundamental Concept 1.5.

Nuclear Reaction – A reaction, as in fission, fusion, or radioactive decay that alters the energy, composition, or structure of an atomic nucleus. Compare **Chemical Reaction**.

Political – Of, relating to, or dealing with the structure or affairs of government, politics, or the state. Or, relating to, involving characteristic of politics or politicians. Or, based on or motivated by partisan or self-serving objectives.

Potential Energy – See Fundamental Concept 1.5.

Power – See Fundamental Concept 1.8.

Primary Energy Source or **Primary Source** – A source of energy found in nature that has not been subject to any human induced energy transfers or transformations. Examples include **fossil fuels**, solar, wind and hydro-power. Compare **Energy Carrier**.

Quality (as in energy) – A measure of the ability of a unit of energy to produce goods or services for people.

Renewable Energy – Energy obtained from sources that are virtually inexhaustible (defined in terms of comparison to the lifetime of the Sun).

Reservoir – A place where a supply of store of something is kept or located.

System – A set of connected things or parts forming a complex whole. In particular, a set of things working together as parts of a mechanism or an interconnecting network. The place one **system** ends and another begins is not an absolute, but instead must be defined based on purpose and situation.

Systems-Based Approach – An approach that emphasizes the interdependence and interactive nature of elements within and external to events, processes and phenomena. An approach that seeks to identify and understand all cause and effect connections related to a given event, process or phenomenon.

Sustainable – Able to be maintained at a steady level without exhausting natural resources or causing severe ecological damage, as in a behavior or practice.

Thermal Energy – See Fundamental Concept 1.2.

Work – See Fundamental Concept 1.1.